UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/823,159	04/13/2004	Chung-Shi Liu	TSM03-0454	4549

43859 7590 06/26/2006

SLATER & MATSIL, L.L.P.
17950 PRESTON ROAD, SUITE 1000
DALLAS, TX 75252

EXAMINER	
PIZARRO CRESPO, MARCOS D	
ART UNIT	**PAPER NUMBER**
2814	

DATE MAILED: 06/26/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/823,159	LIU ET AL.	
	Examiner	Art Unit	
	Marcos D. Pizarro-Crespo	2814	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *24 April 2006*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-35* is/are pending in the application.

4a) Of the above claim(s) *19 and 28-35* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-18 and 20-27* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) *1-32* are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

Attorney's Docket Number: TSM03-0454
Filing Date: 4/13/2004
Claimed Foreign Priority Date: none
Applicant(s): Liu et al.
Examiner: Marcos D. Pizarro-Crespo

DETAILED ACTION

This Office action replies to the response and declaration filed on 4/24/2006.

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after the final rejection mailed on 1/23/2006. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 4/24/2006 has been entered.

Acknowledgment

2. The response and declaration filed on 4/24/2006, responding to the Office action mailed on 1/23/2006, have been entered. The present Office action is made with all the presented arguments and declaration being fully considered. Accordingly, pending in this Office action are claims 1-35.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-7, 13, 14, and 16-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Barth (US 6613664) and Li (US 6008114).

5. Regarding claim 1, Barth shows (see, *e.g.*, fig. 5) most aspects of the instant invention including a semiconductor device **200** comprising:

- ✓ A dielectric layer **210/212**
- ✓ A conductive line **208** underlying the dielectric layer **210/212**
- ✓ A via **213** formed in the dielectric layer and extending into the conductive line **208** to form a via recess in the conductive line (see, *e.g.*, figs. 3 and 4)
- ✓ Via-fill material **218/220/222** filling the via recess and at least partially filling the via, such that the via-fill material is electrically connected to the conductive line **208**

6. Regarding claims 1, 6, 16, and 17, Barth shows most aspects of the instant invention but fails to specify the depth of the via recess. Barth (see, *e.g.*, col.8/ll.63), however, teaches that the via recess lowers the electrical resistance between the conductive line and the via-fill material. Li (see, *e.g.*, fig. 2E) shows a similar device to Barth but also fails to disclose the depth of the via recess. Nonetheless, Li added that the via recess increases the contact area between the via-fill material and the

conductive line (see, *e.g.*, Li/col.3/ll.5-8). Accordingly, at the time of the invention, it would have been obvious to one of ordinary skill in the art to have a via recess in Barth's device to lower the electrical resistance and, as taught by Li, to increase contact area between the via-fill material and the conductive line.

Although Barth/Li teach about the importance of having the via recess, they both fail to specify its depth. The specification, on the other hand, fails to provide teachings about the criticality of having the claimed depth of between about 100-600 angstroms. It has been held that depth differences will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such depth is critical. "Where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the workable ranges by routine experimentation". *In re Aller*, 220 F.2d 454,456,105 USPQ 233, 235 (CCPA 1955).

Since the applicant has not established the criticality (see next paragraph) of the via-recess depth, it would have been obvious to one of ordinary skill in the art to use these values in the device of Barth/Li.

CRITICALITY

7. The specification contains no disclosure of either the critical nature of the claimed depth or any unexpected results arising therefrom. Where patentability is said to be based upon particular chosen dimensions or upon another variable recited in a claim, the applicant must show that the chosen dimensions are critical. *In re Woodruff*, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990).

8. Regarding claim 2, Barth shows (see, *e.g.*, fig. 5) that the via-fill material comprises:

- ✓ A barrier layer **218** at least partially lining interior surfaces of the via recess and at least partially lining interior surfaces of the via

- ✓ A conducting material **220/222**

wherein the barrier layer **218** is located between at least part of the conducting material **222** and at least part of the dielectric layer **210/212**.

9. Regarding claim 3, Barth shows that the conducting material **222** is electrically connected to the conductive line **208** through the barrier layer **218** (see, *e.g.*, fig. 5).

10. Regarding claim 4, Barth shows that the barrier layer **218** comprises tantalum nitride (see, *e.g.*, col.6/ll.33).

11. Regarding claim 5, Barth shows that the conducting material **222** comprises copper (see, *e.g.*, col.6/ll.43).

12. Regarding claim 7, Barth shows (see, *e.g.*, fig. 5) the dielectric layer comprising:

- ✓ A capped layer **210**
- ✓ A layer of insulating material **212** overlying the capped layer **210**

13. Regarding claim 13, Barth shows the insulating material having a dielectric constant less than about 3 (see, *e.g.*, col.1/ll.34 and col.5/ll.58).

14. Regarding claim 14, Barth shows the insulating material comprising spin-on-polymers (see, *e.g.*, col.3/ll.52).

15. Regarding claim 18, Barth shows the conductive line comprising copper (see, *e.g.*, col.5/ll.47).

16. Claims 8, 10-12, 15, and 20-22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Barth/Lin in view of Chooi (US 6436824).

17. Regarding claims 8 and 10-12, Barth/Lin shows most aspects of the instant invention (see, *e.g.*, paragraph 12 above), except for the capped layer comprising

silicon-carbon, having a thickness of less than about 600 angstroms, comprising carbon-doped silicon nitride ($Si_xN_yC_x$), and having a dielectric constant of less than about 4.0. Chooi (see, *e.g.*, col.1/ll.19-21), on the other hand, shows a capped layer that would reduce the capacitance of Barth/Lin's device. Said capped layer comprises silicon-carbon, has a thickness of less than about 600 angstroms, comprises carbon-doped silicon nitride ($Si_xN_yC_x$), and has a dielectric constant of less than about 4.0 (see, *e.g.*, Chooi, col.3/ll.22-23, col.2/ll.56, and col.3/ll.22,26).

It would have been obvious at the time of the invention to one of ordinary skill in the art to use the capped layer suggested by Chooi in the device of Barth/Lin to reduce the capacitance of the device.

18. Regarding claim 15, Barth/Lin show most aspects of the instant invention (see, *e.g.*, paragraph 12 above). Although Barth/Lin describe an improved via and talked about the importance of miniaturization in the semiconductor industry, they fail to specify the size of the via (see, *e.g.*, Barth/col.1/ll.7-10,21-25). The specification, on the other hand, fails to provide teachings about the criticality of having a via of less than about 900 angstroms. It has been held that differences in thickness will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such thickness is critical. "Where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the workable ranges by routine experimentation". *In re Aller*, 220 F.2d 454,456,105 USPQ 233, 235 (CCPA 1955).

Since the applicant has not established the criticality (see paragraph 7 above) of the via thickness, it would have been obvious to one of ordinary skill in the art to use these values in the device of Barth/Lin.

19. Regarding claim 20, Barth/Lin shows most aspects of the instant invention including (see, *e.g.*, Barth/fig.5):

- ✓ A dielectric layer comprising:
- – An insulating material layer **212**
- – A capped layer **210**
- ✓ A conductive line **208** underlying the dielectric layer
- ✓ A via formed in the insulating material layer, through the capped layer, and extending into the conductive line **208** to form a via recess in the conductive line (see, *e.g.*, Barth/figs. 3 and 4)
- ✓ Via-fill material **218** filling the via recess and at least partially filling the via, such that the via-fill material **218** is electrically connected to the conductive line **208**

Barth also shows the capped layer **210** comprising silicon nitride, but fails to show the layer having a dielectric constant of less than about 4.0. Chooi (see, *e.g.*, col.5/ll.51), on the other hand, shows a capped layer that would reduce the capacitance of Barth/Lin's device. Said capped layer is carbon-doped silicon-nitride having a dielectric constant of less than about 4.0 (see, *e.g.*, Chooi, col.1/ll.19-21, col.3/ll.20-26).

It would have been obvious at the time of the invention to one of ordinary skill in the art to use the capped layer suggested by Chooi in the device of Barth/Lin to reduce the capacitance of the device.

20. Regarding claim 20, see the comments stated above in paragraphs 6 and 7 with respect to claims 1, 6, 16, and 17, which are considered repeated here.

21. Regarding claim 21, Barth shows the conductive line **208** is made of copper (see, *e.g.*, col.5/ll.47).

22. Regarding claim 22, Chooi (see, *e.g.*, col.3/ll.22) shows the capped layer comprising silicon carbon and Barth (see, *e.g.*, fig. 5) shows it is located between the insulating material layer **210/212** and the conductive line **208**.

23. Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Barth/Lin/Chooi in view of Wang (US 20050080286).

24. Regarding claim 9, Barth/Lin/Chooi shows most aspects of the instant invention (see, *e.g.*, paragraph 17 above). Chooi also shows the capped layer comprising carbon-doped silicon-nitride and teaches that said layer reduces the capacitance of the device (see, *e.g.*, Chooi/col.1/ll.20). Although Barth/Lin/Chooi teach about the importance of the carbon-doped silicon-nitride capped-layer, they fail to specify the carbon concentration in the layer. The specification, on the other hand, fails to provide teachings about the criticality of the claimed carbon concentration of 30%. Wang, another piece of art, discloses a silicon-nitride capped-layer having a carbon concentration of about 30%.

Since the applicant has not established the criticality (see paragraph 7 above) of the claimed carbon concentration in the silicon nitride layer and since this concentration is in common use in similar layers in the art, it would have been obvious to one of ordinary skill in the art to use the claimed value in the device of Barth/Lin/Chooi.

25. Claims 23-27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Barth in view of Lin and Wang.

26. Regarding claim 23, Barth and Lin shows most aspects of the instant invention including a semiconductor device comprising (see, *e.g.*, Barth/fig. 5):

- ✓ A dielectric layer comprising:
- – An insulating material layer **212**
- – A capped layer **210**
- ✓ A copper-based conductive line **208** underlying the dielectric layer
- ✓ A via **213** formed in the insulating material layer, through the capped layer, and extending into the conductive line **208** to form a via recess in the conductive line (see, *e.g.*, figs. 3 and 4)
- ✓ Via-fill material **218** filling the via recess and at least partially filling the via, such that the via-fill material is electrically connected to the conductive line

Barth (see, *e.g.*, col.5/ll.52) also shows the capped layer **210** comprising silicon nitride, but fails to show the layer also comprising carbon. Wang (see, *e.g.*, par. 0004), on the other hand, teaches that incorporating carbon into Barth's capped layer would improve its film qualities.

It would have been obvious at the time of the invention to one of ordinary skill in the art to include carbon into Barth/Lin's capped layer, as suggested by Wang, to improve the qualities of the film.

27. Regarding claims 23, 26 and 27, see the comments stated above in paragraphs 6 and 7 with respect to claims 1, 6, 16, and 17, which are considered repeated here.

28. Regarding claim 24, Wang shows the capped layer comprising at least 30% carbon (see, *e.g.*, par. 0087).

29. Regarding claim 25, see the comments stated above in paragraph 18 with respect to claim 15, which are considered repeated here.

Response to Declaration under 37 CFR 1.132

30. The declaration under 37 CFR 1.132 filed on 4/24/2006 is insufficient to overcome the rejection of claims 1-18 and 20-27 as set forth in the present Office action.

31. Although the examiner appreciates applicant's effort to show the criticality of the claimed range of about 100 to about 600 angstroms, full credit could not be given to the evidence submitted. For instance, the applicant has failed to satisfactorily explain the tabulated dated on page 2 of the declaration. The labels on the table, *e.g.*, Rs shift, Ar 150, Ar 40, No Ar, Stress Migration Fail Die, >10%(Ref.), and >500%(fail), lack any explanation whatsoever so that meaningful information could be obtained to support any showing of criticality. Likewise, the meaning of the tabulated numbers is not clear. For example, the numbers 14, 15, 16, 1, and 0, by themselves are just merely numbers and

could not support the showing of criticality for the claimed range without a proper discussion about their significance.

32. The charts on page 3, on the other hand, seem to contradict applicant's explanation in the body of the declaration. As set forth on the last sentence on page 2 of the declaration, longer mean times, t50, are better. However, from the chart showing t50 for 90, 250, and 900 angstroms, it is seen that the longer t50 corresponds to those via recess having a depth outside the claimed range, *i.e.*, 900 angstroms.

33. In conclusion, the applicant has failed to establish a basis for judging the practical significance of the data presented in the declaration. Please note that the applicant has the burden of explaining the data in any declaration he proffers as evidence of non-obviousness. See Ex parte Ishizaka, 24 USPQ2d 1621, 1624 (Bd. Pat. App. & Inter. 1992).

Conclusion

34. Papers related to this application may be submitted directly to Art Unit 2814 by facsimile transmission. Papers should be faxed to Art Unit 2814 via the Art Unit 2814 Fax Center. The faxing of such papers must conform to the notice published in the Official Gazette, 1096 OG 30 (15 November 1989). The Art Unit 2814 Fax Center number is **(571) 273-8300**. The Art Unit 2814 Fax Center is to be used only for papers related to Art Unit 2814 applications.

35. Any inquiry concerning this communication or earlier communications from the examiner should be directed to **Marcos D. Pizarro-Crespo** at **(571) 272-1716** and between the hours of 10:00 AM to 8:30 PM (Eastern Standard Time) Monday through

Thursday or by e-mail via Marcos.Pizarro@uspto.gov. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wael Fahmy, can be reached on (571) 272-1705.

36. Any inquiry of a general nature or relating to the status of this application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

37. The following list is the Examiner's field of search for the present Office Action:

Field of Search	Date
U.S. Class / Subclass(es): 257/750-766	6/19/2006
Other Documentation:	
Electronic Database(s): EAST (USPAT, EPO, JPO)	6/19/2006

Marcos D. Pizarro-Crespo
Patent Examiner
Art Unit 2814
571-272-1716
marcos.pizarro@uspto.gov

MDP/mdp
June 19, 2006